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ABSTRACT

To estimate computer needs at a higher education institution, the major types of users and their future needs should be determined. In a large or complex university, three major groups of users are typically instructional, research, and administrative. After collecting information on the needs of these users, the needs can be translated into machine characteristics and capabilities. The two major instructional uses of computers are computer-assisted instruction and developing and grading tests. Three types of research activities for which a computer is required are data processing, scientific analysis, and utility utilization. Administrative uses of computer services involve maintenance, analysis, and reporting from large data bases. A questionnaire that can be used to collect data on computer needs from the three major users is included. A discussion about making projections of future needs from estimates of use is presented. (SW)

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Balancing Computer Resources with Institutional Needs

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BALANCING COMPUTER RESOURCES WITH INSTITUTIONAL NEEDS

Computers play a vital role in educational institutions and agencies. Over the last decade, dependency on computers has increased tremendously. The technological advances in hardware and software have been exciting, but cost pressures have caused many decision makers to evaluate their current computer resources and to carefully plan any further development or expansion of existing equipment. Such planning depends heavily on an accurate assessment of computer needs.

The traditional forecasting techniques which use some form of trend analysis are of limited value when determining future computer needs. After all, prior use may be a function of equipment available rather than an indicator of the actual needs of users. Future use will soon expand to fit and fill the capacity of existing equipment. An even more serious problem is the difficulty presented by mutually exclusive knowledge. Experts in computer technology, for example, have little insight into the future computer needs in other curricula. Advisors may not know the specific details of computer use in courses taken by their majors in other departments. Faculty teaching courses which use the computer as a tool do not know of trends in other courses which their students take. A final problem is that internal cost procedures for computer use may be established to modify behavior (for example, use disks, not cards) rather than to reflect the costs for various uses.

An estimate of computer needs should be based on information from knowledgeable individuals augmented with institutional data on specific computer use. One needs to answer the following questions:

(1) Who are the major types of users?

(2) What will be their needs at some future date, for example, in five years?

Major User Groups

In a large or complex university, three major groups of users are typically instructional, research, and administrative. Instructional use of computers can be divided into "instruction about computing" and "instruction with computers" (Mosmann, 1976). Instruction about computing concerns learning about computers and programming, whereas instruction with computers concerns the use of the computer as a tool. Research users include several groups which range from those in the social sciences who use statistical program packages (BMD, SAS, SPSS) on relatively small data sets to those in the natural sciences who need large core and have heavy computational time requirements. Administrative use of computers is typically an input/output activity with large data storage requirements.

Future Needs of Major User Groups

In order to ascertain the future needs of the major user groups, a questionnaire can be used to collect data from those involved in instruction, research, and administration. An example of such a questionnaire is included in the appendix.

Instructional Needs

The two major instructional uses of computers are (1) courses in which programming skills are taught and (2) courses in which the computer must be used to complete assignments. Two secondary uses of the computer are (1) computer assisted instruction (CAI) and (2) developing and grading tests.

Responses to two of the questions on the questionnaire will provide estimates for the two major instructional uses of the computer. The two questions (questions 3 and 4) are "What percent of your majors will require each of the following levels of programming skill?" and "What percent of your majors need access to computing at each of these levels in order to perform their class homework assignments ... ?" The questions and response scales on instruction were adapted from prior work by Charles Mosmann (1976).

Based on departmental estimates, projections can now be made for the skill levels needed by undergraduate and graduate majors. Since the response to this question is in terms of percentage of students who need the skill, one can multiply the percentage requiring a given skill by the projected fall headcount enrollment for the appropriate year for the level of student (graduate or undergraduate) for each department. The results are then summed over departments. Remembering that undergraduates will have four years to take the computer related courses and many graduate students will have acquired the skills before entering graduate school, it appears useful to divide the results for the undergraduates by four. The results are further reduced by assuming that one of four graduate students have not previously developed the necessary computer skills and will do so over a two-year period. This procedure reduces the estimate received from the departments, but gives a more reliable estimate. The results from this question provide information on the number of basic and advanced computer courses needed.

A somewhat simple procedure can be used to compute the projected enrollment in courses where the computer represents a tool for completing assignments (question 4). The number of courses using the computer as a tool for a

"typical" major is determined by multiplying the percentage in a response category by the midpoint of that category. For example, in question 4, the responses called for the percentage of undergraduates who need access to the computer each year.

Assuming responses along the following lines, one can start the process of looking toward the future:

Question 4: What percentage of your majors need access to computing at each of these levels in order to perform their class homework assignments?

	Percent Undergraduates	
	Current	Projected
a. No computer use for coursework	5	0
b. Occasional access to computer (one or two courses per year)	20	10
c. Frequent access to computer (three to five courses per year)	50	70
d. Continuous access to computer (more than five courses per year)	25	20

The first step is to multiply the midpoint of each category (or response choice) by the percentages.

a.	0	x	5	=	0	0	x	0	=	0
b.	1.5	x	20	=	30	1.5	x	10	=	15
c.	4	x	50	=	200	4	x	70	=	280
d.	6	x	25	=	150	6	x	20	=	120
					380					415
			$\frac{380}{100}$	=	3.80			$\frac{415}{100}$	=	4.15

The material now in hand tells one that 3.8 courses in a particular department currently require access to the computer, and it is anticipated that this number will rise to 4.15 in the next five years. The ratio of projected to current demand represents the increased (decreased) use, and, when multiplied by the projected headcount for a major, produces an estimate of the impact the department will have on computer use relative to its current headcount. In other words, for a stable department, current headcount at twice the use is "equivalent" to twice the headcount at current use.

The projected student figure is multiplied by the ratio of projected to current computer demand to obtain an adjusted headcount figure. This procedure is illustrated below for majors in mathematics:

	19XX - XX	19XX - XX (5 years later)
1. Average use	3.80	4.15
2. Headcount majors	65	91
3. Adjusted headcount majors	4.15/3.80 x 91 = 99.38	

Before continuing with the process, one needs to determine the total activity in each department for all students taking courses in it. In the Mathematics Department, for example, one finds mathematics majors, biology majors, computer science majors, etc. Using an induced workload matrix, one can obtain the current course enrollments in a given department for all the students across the university. Assuming that the induced workload matrix reveals that 195 credit hours are currently being taken by 65 mathematics majors, this means that the Mathematics Department teaches an average of three credit hours per mathematics major during the current quarter.

Multiplying this average credit hour value by the adjusted projected majors yields the total number of projected credit hours for mathematics majors. Following this same procedure for all other majors taking courses in mathematics and summing the results, one can obtain the total number of projected credit hours for mathematics. The following example illustrates the process:

Current and Projected Hours Taught by the Mathematics Department

	Current Hours	÷ Majors =	Average Hours	Adjusted Projected Majors	Projected Hours
a. Mathematics Majors	195	65	3	99.38	298.14
b. Biology Majors	42	42	1	44.00	44.00
c. Computer Science Majors	150	75	2	92.00	184.00
	387				526.14

The credit hours anticipated in five years are divided by the current hours to yield a factor which will be used in determining future computer needs:

$$\frac{526.14}{387} = 1.36$$

One needs to obtain from the computing center a current, detailed computer use summary for each department. Such a summary, hopefully, will be available--most centers in complex universities must keep them for charging and overhead purposes. The current level of use for such items as number of cards read, CPU time, I/O time, and other breakdowns used at the institution can be multiplied by the factor previously obtained.

By following this same procedure for each department and summing over all departments, the amount of computer capability needed five years from now can be determined. The results thereby obtained can be supplemented with materials

from other questions relating to instruction (the following questions are paraphrased from the questionnaire):

Question 5. What uses are anticipated for computer assisted instruction?

Question 6. What courses will require special computer support?

Question 7. What other needs will you have?

Question 8. What activity is anticipated for test development/scoring?

The indicators collected on instructional needs provide information on anticipated courses and on uses for the computer. From such material one can develop an idea of anticipated needs for the future.

Research Needs

Research use of the computer has traditionally been viewed as requiring "many languages, specialized measuring devices, a powerful library, and high speed core" (Computer Services, 1973). Within this broader description, it has been accepted that some research depends on analysis of small data sets using availble statistical program packages while other research requires a large core and high-speed memory.

The second part of the analysis of needs is to identify and to quantify types of research users of the computer. In this step one requests that each type of research user identify the major type of research activity for which a computer is required by classifying the computer needs into three categories. For each category selected, a separate questionnaire is then completed. The three major categories, which appear below, are based upon responses from a group of research users who answered the questionnaire. Using a maximum likelihood grouping technique (Wolfe, 1971), these responses were empirically grouped into three types of users: data processing, scientific analysis, and utility utilization.

Data Processing. These projects are characterized by the need to store and retrieve large data bases with a minimal amount of computations per element accessed. The actual programs require a moderate amount of core but require a great deal of input and output (frequently from disk). Projects of this nature are frequently found in agribusiness, entomology, biology, environmental studies requiring monitoring, and developing concordances (for example, English). Terminals are normally used to edit data or for information retrieval.

Scientific Analysis. This type of computer use normally requires little input or output. It uses a large amount of core and a large number of complex operations, frequently using an iterative algorithm. This requirement produces long jobs relative to data requirements. Projects of this type are frequently found in engineering work as well as other scientific areas such as mathematics, computer science, and chemistry. Terminals are frequently used to compile and control execution of programs.

Utility Utilization. This utilization implies the presence of a relatively complex software system which is essentially transparent to the user. The programs normally are very short in CPU time with limited input/output and limited core requirements. These projects include most uses of the Statistical Analysis System (SAS), Biomedical Division programs (BMD), and numerous others. In some systems computer assisted instruction may produce a similar load on a machine. Frequent users of computers in this area include many in social science, home economics, and education. Terminals are primarily used for entering data or programs (based on a limited number of control cards).

After one identifies the types of research activity frequently undertaken in a department/division, the next step is to derive a profile of computer

use for each department on a weekly basis. Item 10 of the questionnaire concerns the current and projected computer use and the requirements of a typical job in terms of core required, input/output records, time for batch programs, and time at a terminal. The responses to this question will provide information on future computer needs. An example of findings is given below:

		Items Checked	Midpoint of Range*
10a.	Computer use	3 to 5 programs per week	4
b.	Core requirements	200 - 399 K	300
c.	Input cards	500 - 999	750
d.	Output records (cards/paper)	1000 - 3999	2500
e.	Time for batch programs	10 to < 30 minutes	20
f.	Input/output records (tape/disk)	1000 - 3999	2500

*Use the midpoint of range unless researcher gives a specific number.

Combining the responses to Question 10, one may obtain weekly computer requirements for a given research activity as follows:

Input cards: 750 x 4 = 3,000

Output records (cards/paper): 2,500 x 4 = 10,000

CPU time: 20 min. x 4 = 80 min.

I/O records (tape/disk): 2,500 x 4 = 10,000

The results are then summed for each type of research user by department.

Administrative Needs

Administrative uses of computer services essentially involve the maintenance, analysis, and reporting from large data bases. Anticipated administrative needs should be obtained from the major divisions concerned.

There are two key questions to ask:

1. In the next five years, what administrative systems do you plan to expand?

2. In the next five years, what new administrative activities will be computerized?

Once this information has been collected, one can extrapolate from similar on-going administrative uses to get an estimate for computer needs. This procedure, however, will not work when installing a major new system such as the IMS software of IBM. At that point it is necessary to get estimates from the customer engineers, the computer staff, and other institutions which have placed such software into operation.

Summary

After collecting information on the needs of the instructional, research, and administrative users, one can translate these needs into machine characteristics and capabilities.

The procedures developed in this paper enable an institutional researcher to estimate the need for computer resources at an institution. While this approach does not answer all questions, it provides information that is somewhat independent of existing facilities and their costing structure. The collection procedure does not require either technical estimates from those unfamiliar with computer developments or estimates about the skills to use the computer.

References

Computer Services, Ohio Board of Regents, 88 E. Broad St., Suite 700, Columbus, Ohio 43215, 1973, p. 19.

Mosmann, Charles. Evaluating Instructional Computing. Irvine, California: University of California Computing Facility, 1976.

Wolfe, John H. Normix 360 Computer Program, SRM 72-4. San Diego, California: Naval Personnel and Training Research Laboratory, 1971.

PLEASE RETURN TO:

Questionnaire on Computer Needs

Return Date: _____

Department/Division _____

Person Completing Form: _____

Part I: Instructional Needs

1. What are the major current uses of computers in your division/department? (Include departmental minicomputers, off-campus computers, and the Computing Center.)

2. What assumptions about availability of software, hardware, facilities, and services do you make in planning for computer services (e.g.. turnaround, software, etc.)?

For questions 3 to 8, project in terms of Academic Year 19XX-XX.

3. What percent of your majors will require each of the following levels of programming skill?

	% Undergraduate Majors	% Graduate Majors
a. Exposure through noncredit short courses	_____	_____
b. One or two credit courses in programming	_____	_____
c. Advanced skills (3 to 5 courses including advanced courses)	_____	_____
d. Very strong skills (6 or more courses)	_____	_____
e. No courses required	_____	_____
	100%	100%

4. What percentage of your majors need access to computing at each of these levels in order to perform their class homework assignments (exclude courses covered in 3 above; include courses students take regardless of which department offers the course; exclude variable credit research courses and computer aided/assisted instruction):

	% Undergraduate		% Graduate	
	Current	Projected	Current	Projected
a. No computer use for coursework	_____	_____	_____	_____
b. Occasional access to computers (one or two courses per yr.)	_____	_____	_____	_____
c. Frequent access to computers (three to five courses per yr.)	_____	_____	_____	_____
d. Continuous access to computers (more than five courses per yr.)	_____	_____	_____	_____

PLEASE RETURN TO:

Give a short description of typical use of computer for the courses covered in 4. Note projected changes from current use.

5. What level of use of computer aided/assisted instruction should exist in your department/division? (If none, go to question 6.)

   a. Computer support required (hardware, facilities, etc.)

   b. Specialized software desired _____.

   c. Level of activity (e.g., number of sections in which used per year, total number of students taking course per year, etc.)

6. What courses other than those reported above will be offered by your division/department requiring special computer support? (If none, go to question 7.)

   a. Number of sections involved each year _____

   b. Number of students enrolled in these sections each year _____

   c. Use of the computer in the process _____

7. What other needs will you have? (Include computer-related support such as equipment repair, consulting, instruction, etc.).

8. What level of activity do you anticipate for test development/scoring (number of students per class, number of classes)?

PLEASE RETURN TO:

Department/Division _____

Person Completing Form: _____

Part II: Research Needs: Current and Projected

Please complete a different Part II for each major type of research activity in your division/department which requires a substantially unique use of the computer. Include research use of computers in variable credit courses (e.g., thesis, independent study, etc.). See Annex A for three major types of Research Activity.

9. Short Description of research anticipated:

   a. Involvement of the computer

   b. Computer hardware/software needed

   c. Other services needed

10. Report the estimated level of computer use.

	Current	Projected
a. 1 to 2 programs per week	_____	_____
3 to 5 programs per week	_____	_____
6 to 10 programs per week	_____	_____
11 to 25 programs per week	_____	_____
26 to 40 programs per week	_____	_____
41 to 60 programs per week	_____	_____
61 to 80 programs per week	_____	_____
over 80 programs per week (specify)	_____	_____

While it is difficult to determine the characteristics of all types of computer use, the following are some parameters which apply in most cases. If the following are not applicable in your situation or if you are unable to complete this part of the questionnaire because of lack of experience with the anticipated project, omit the following and give an expanded description of the necessary computer use to support such activity.

Check one category for each set which is most representative of a typical job for the specific type of research activity you are describing.

	Current
b. Core requirements:	
< 200 K	_____
200 - 399 K	_____
400 - 599 K	_____
600 K and up (specify)	_____

PLEASE RETURN TO:

Current

c. Input cards:

0 - 499	_____
500 - 999	_____
1000 - 3999	_____
4000 and up (specify)	_____

d. Output records (80-130 col. equivalent):

0 - 999	_____
1000 - 3999	_____
4000 - 14999	_____
15000 and up (specify)	_____

e. Time for a typical Batch program:

< 30 seconds	_____
30 seconds to < 2 minutes	_____
2 to < 10 minutes	_____
10 to < 30 minutes	_____
30 minutes and up (specify)	_____

f. Input/Output records for tape and/or disk:

0 - 999	_____
1000 - 3999	_____
4000 - 14999	_____
15000 and up (specify)	_____

g. Time at a terminal:

< 10 minutes	_____
10 to < 30 minutes	_____
30 minutes to < 2 hours	_____
2 hours and up (specify)	_____

11. How much disk storage will be required? (Note: One track currently holds about 160 card images.)

20 tracks or less	_____
21-100 tracks	_____
101-500 tracks	_____
Over 500 tracks (specify)	_____

Note: Categories in Question 10 and 11 may need to be adjusted for local machine characteristics.

Annex A: Three Types of Research Activity

I. Data Processing

These projects are characterized by the need to store and retrieve large data bases with a minimal amount of computations per element accessed. The actual programs require a moderate amount of core but require a great deal of input and output (frequently from disk). Projects of this nature are frequently found in agribusiness, entomology, biology, environmental studies requiring monitoring, and developing concordances (for example, English). Terminals are normally used to edit data or for information retrieval.

II. Scientific Analysis

This type of computer use normally requires little input or output. It uses a large amount of core and a large number of complex operations, frequently using iterative algorithms. This requirement produces long jobs relative to data requirement. Projects of this type are frequently found in engineering work as well as other scientific areas such as mathematics, computer science, and chemistry. Terminals are frequently used to compile and control execution of programs.

III. Utility Utilization

This utilization implies the presence of a relatively complex software system which is essentially transparent to the user. The programs normally are very short in CPU time with limited input/output and limited core requirements. These projects include most uses of the Statistical Analysis System (SAS), Biomedical Division programs (BMD), and numerous others. In some systems computer assisted instruction may produce a similar load on a machine. Frequent users of computers in this area include many in social science, home economics, and education. Terminals are primarily used for entering data or programs (based on a limited number of control cards).